SOME ECONOMIC IMPLICATIONS OF EXTENDING CROP ROTATIONS*

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In assessing the economic implications of extending crop rotations, the normal prerequisite would be to define exactly what is meant by the term and identify specific crop rotations. In one sense, the term probably implies that the percentage of summerfallow in the rotation is reduced. It also means deriving crop rotations which achieve one or more of the following:

(1) increase soil fertility;

(2) improve soil texture and reduce soil salinity;

(3) maximize the use of available moisture, where available moisture is defined as the moisture entering the soil profile which is in excess of the wilting point and excludes moisture lost through drainage and rainfall; and

(4) protect the soil from water and wind erosion.

There may be other factors but these seem to be the ones that are most obvious. You will note one point I have not mentioned is diversification. If risk is defined as the variance in income, expanding crop rotations is not a means of reducing risk. Mathematically, total income variance can not be reduced by adding enterprises to the same resource

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* Paper presented to the Soil Fertility Workshop, Saskatoon, February 12, 1975.

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base, unless the covariance of incomes between the enterprises is negative.

Specifying rotations depends on the assessment of the above factors in relation to the objectives of the producer and on the particular location, where location is a collective term for such variables as soil type, amount and incidence of rainfall, wind and local and regional markets. Rather than looking at specific rotations I have chosen a more general approach and will attempt to do the three following things.

1. Investigate the costs of increasing the size of the planting and harvesting components of a machinery complement and the implications for acreage capacities of the complements;

2. Investigate the costs of adding haying equipment to a machinery complement, and

3. Discuss the feeding implications for a livestock producer of having forage available.

1. Expanding the capacity of machinery complements.

It is assumed that the planting and harvesting machines are the most critical machines in the complement from the standpoint of timeliness of operations. I have assumed the seeding operation is done with a discer which has a seed and fertilizer attachment. The three sets of machines or sub-complements I have considered are specified in Table 1.

Table 1: Machinery Sub-Complements Analyzed

Sub-Complement Number	Discer	Swather	Combine[a]
1	16 ft.	12 ft. P.T.O.	12 ft. P.T.O.
2	24 ft.	18 ft. P.T.O.	14-18 ft. S.P.
3	30 ft.	24 ft. P.T.O.	24 ft. S.P.

[a]Size of combines is defined as the size necessary to handle a swath of the size specified.

These sets of machines are analyzed on the basis of ownership costs, namely depreciation, interest on investment, insurance and housing and repair costs. The repair costs are based on the normal lifetime repairs on a machine as a percentage of original cost and the expected useful life of the machine in years.

The coefficients used to compute the machinery costs are presented in Table 2.

Table 2: Machinery Cost Calculation Coefficients

Coefficient	Machine			
	Discer	Swather	PTO Combine	SP Combine
Life in Years	15	15	12	12
Salvage Value	10%	10%	15%	15%
Repairs	110%	50%	30%	40%
Field speed in MPH	4.5	4.5	3.5	4.0
Field efficiency	80%	70%	75%	75%

The computed performance rates and the original costs of each machine are presented in Table 3.

Table 3: Machinery Performance Rates and Original Costs

Machine	Performance Rate in Ac/Hour	Original Cost
Discers		
16 ft.	6.5	$4261
24 ft.	9.8	5566
30 ft.	12.3	6219
Swathers		
12 ft.	4.6	1596
18 ft.	6.9	2355
24 ft.	9.2	3308
Combines		
Small	3.8	13079
Medium	6.5	20632
Large	8.7	26432

The annual costs were computed using the following formulas:

1. Depreciation =

$$\frac{\text{Original Cost} - \text{Salvage Value}}{\text{Years of Life}}$$

2. Interest on Investment =

$$\frac{\text{Original Cost} + \text{Salvage Value}}{2} \quad \text{X} \quad \text{Interest Rate}$$

The interest rate was set at 10%

3. Insurance and Housing = 1% of original value.

4. Repairs =

$$\frac{\text{Repair Rate X Original Cost}}{\text{Years of Life}}$$

The costs are summarized in Table 4 by machine size and in Table 5 by machinery sub-complement.

Table 4: Summary of Annual Costs by Machine and Machine Size

Machine	Dep.	Int.	Ins. & Hous.	Repairs	Total
Discer					
16 ft.	$ 256	$ 234	$ 43	$ 312	$ 845
24 ft.	334	306	57	408	1105
30 ft.	373	342	62	456	1233
Swathers					
12 ft.	96	88	16	53	253
18 ft.	141	130	24	78	373
24 ft.	198	182	33	110	523
Combines					
Small	926	752	131	345	2154
Medium	1461	1286	206	688	3641
Large	1872	1520	264	881	4537

Table 5: Summary of Total Annual Ownership Cost by Machinery Sub-Complement

Sub-Complement Number	Discer	Swather	Combine	Swather & Combine	Discer, Swather & Combine
1	845	253	2154	2407	3252
2	1105	373	3641	4104	5119
3	1233	523	4537	5060	6293

These total costs figures will be more meaningful if put on a per acre basis. The per acre calculations are shown in Table 6.

Table 6: Total Annual Ownership Costs of Machinery Sub-Complements in Dollars per Acre By the Number of Acres Completed

	Sub-Complement Number 1		2		3	
No. of Acres	Incl. Discer	Not incl. Discer	Incl. Discer	Not incl. Discer	Incl. Discer	Not incl. Discer
200	$16.26	$12.03	$20.60	$20.07	$31.47	$25.03
400	8.13	6.02	12.80	10.03	15.73	12.65
600	5.42	4.01	8.53	6.69	10.47	8.43
800	4.06	3.01	6.40	5.02	7.87	6.32
1000	3.25	2.41	5.12	4.01	6.29	5.06
1200	2.71	2.01	4.26	3.34	5.24	4.22
1400	2.32	1.72	3.65	2.87	4.49	3.61

In order to try to relate these figures back to specific rotations in terms of the number of acres, I estimated the capacity of each sub-complement, using the combine as the base of calculation. I assumed that a producer would set his goals at completing the combining of his crop in a total of 14 working days. I also assumed the average length of day to be 10 hours. The capacities of the three sub-complements are then 532 acres, 910 acres and 1218 acres respectively. If you base the capacity on the discer and assume 10 days of 10 hours each, the comparable figures are 650, 980 and 1230 acres respectively.

The costs per acre presented in Table 6 are presented in graphic form in Figure 1. The horizontal line represents the

Table 7: Haying Machinery Systems Analyzed

	Machine	Size	Cost	Life in Years	Salvage Value	Repair Rate
Mowing						
1	Mower	7 ft.	$ 978	15	10%	40%
	Rake	7 ft.	980	15	10	35
2	Mower - Cond.	9 ft.	4100	15	10	65
	Rake	11 ft.	1200	15	10	35
Packaging						
1	Standard Baler	16 T/hr.	3454	15	10	50
	Bale Wagon	70 bales	7500	15	10	50
2	Large Round Baler	1500 lb.	4840	15	10	50
	Bale Mover		(est.)800	15	10	40

The summary of the annual costs of each machine is presented in Table 8 and in Table 9 the costs are summarized by haying system. In Table 10 the system costs are computed on a per acreage basis.

Table 8: Summary of Annual Cost for Haying Equipment

Machine	Dep.	Int.	Ins. & Hous.	Repairs	Total
Mower	$ 59	$ 54	$10	$ 26	$ 149
Rake 7 Ft.	59	54	10	23	146
Mower - Cond.	246	226	41	178	691
Rake 11 Ft.	72	66	12	28	178
Baler - Standard	207	195	35	115	552
Bale Wagon	450	412	75	250	1187
Baler - Large Rd.	290	266	48	161	665
Bale Mover	48	44	8	21	121

Table 9: Summary of Total Annual Ownership Costs of Haying Machinery Systems

System Number	Mower	Rake	Baler	Handling	Total
1	$149	$146	$552	$1187	$2034
2	149	146	665	121	1081
3	691	178	552	1187	2608
4	691	178	665	121	1655

Table 10: Total Annual Ownership Costs of Haying Systems by the Number of Acres Completed in Dollars per Acre

System Number	100	200	300	400	500	600
1	20.34	10.17	6.78	5.08	4.07	3.39
2	10.81	5.40	3.60	2.70	2.16	1.80
3	26.08	13.04	8.69	6.52	5.21	4.35
4	16.55	8.27	5.52	4.13	3.31	2.76

It is of course, imperative at this point that I emphasize that this analysis of forage handling and specific haymaking equipment is very incomplete. I have not included storage costs and labor charges in my analysis. The objective was solely to estimate the magnitude of the major costs of adding haymaking equipment to the machinery complement.

3. Economic Implications of Forage Production

In addition to the production costs, the market implications are an important consideration in making the decision to grow a forage crop in the crop rotation. Computing the costs and weighing these against the returns assumes that a market is in fact available for the product. In the case of hay, the market can be a cash market or it can be home farm utilization; that is, marketing the crop directly through livestock. The latter alternative may necessitate the purchase of livestock which opens up a number of economic problems. In addition to the purchase of cattle, other facilities will have to be provided such as water facilities, fences, holding pens and possibly winter shelter.

Including a forage crop in the crop rotation is a relatively long run decision. It probably means an initial commitment of at least four or five years to the proposed plan, although it is not an irrevocable decision and the initial rotational plan can be altered or abandoned.

Recently there has been increased discussion of forages replacing grain as the nutrient source for livestock. For example, at the recent Federal-Provincial Outlook Conference, F.E. Payne stated that if there is a bright spot for beef cattle in Canada, it is where, due to geographic and climatic conditions, farmers are able to grow large quantities of roughage. If there is no softening of feed grain prices, we will see a great deal more roughage feeding in the future.

To put this problem in proper prospective, a brief discussion of the decision making framework faced by the producer is in order.

To illustrate, let's assume that a producer can select various combinations of alfalfa hay and grain to feed beef calves. These combinations are shown on the left hand side of Table 11. These are the combinations of hay and grain that will produce a 300 lb. gain on the calf. The third column shows the substitution ratio or the pounds of grain that can be substituted for 100 lbs. of hay to maintain the same level of output. This then is the physical relationship of the two inputs. The economic problem is to find the least cost combination. This can be done by equating the ratio of the prices of the two inputs to the substitution ratio or finding the point where the two ratios are equal (this is easier than computing the cost of each combination and arrives at the same conclusion).

The initial question becomes what are the prices of the two inputs going to be? The price ratios are shown in Table 12 for combinations of hay and grain prices where hay ranges from one cent per pound to four cents per pound and grain ranges from three cents per pound to seven cents per pound.

Comparing the ratios in Table 11 with those in Table 12, it can be seen that selecting the most economical feeding practise is very much influenced by the relative prices of the inputs. A producer may not, of course, purchase his feed requirements but the prices do represent his opportunity cost of feeding versus selling the crops, if they are home grown.

Table 11: Grain - Alfalfa Hay Combinations Necessary to Produce a 300 Pound Gain on Beef Calves[a]

(1) Alfalfa Hay in Pounds	(2) Grain in Pounds	(3) Substitution Ratio[b]
200	1968	
		200/200 = 1.00
400	1768	
		174/200 = .87
600	1594	
		150/200 = .75
800	1444	
		128/200 = .64
1000	1316	
		108/200 = .54
1200	1208	
		88/200 = .44
1400	1120	
		74/200 = .37
1600	1046	
		62/200 = .31
1800	984	
		52/200 = .26
2000	932	

a The source for the combinations from 1000 to 2000 lbs. of hay is Miscellaneous Paper 98, Oregon State University Experiment, 1960. The combinations from 200 to 800 lbs. of hay is a hypothetical extension of the experimental data.

b Change in grain consumed divided by change in hay consumed.

Table 12: Price Ratios for Combination of Alfalfa Hay and Grain Prices[a]

Grain Price in Dollars Per Pound	Hay Price in Dollars Per Pound .01	.02	.03	.04
.03	.33	.67	1.00	1.33
.04	.25	.50	.75	1.00
.05	.20	.40	.60	.80
.06	.17	.33	.50	.67
.07	.14	.29	.43	.57

a Price of hay per pound divided by price of grain per pound.

In summary, again it needs to be pointed out that the figures in Table 11 represent only one experimental example and were used for illustration purposes. In the long run the apparent economic advantage of producing forage as an alternative feed source for livestock in Saskatchewan may or may not persist.